



Evolution



New ideas of species change

- Beginning in the 1700's scientists accumulated evidence which was in contrast to a literal translation of the bible
- Research in some areas led to a series of new ideas
 - Geology
 - Fossils
 - Biogeography



Geological Evidence

- Charles Lyell's *Principles of Geology*
 - **Uniformitarianism**
 - Proposed the idea that the physical structure of the Earth is the result of cycles (ex. mountain building, erosion)
 - These processes have been going on since the beginning of the earth and continue today
 - These cycles take a very long time to complete, and may be so slow as to make them hard to detect
 - This idea leads to the suggestion that the Earth may be older than previously thought



Geological Evidence

- **Steno's Law of Superposition**

- rocks are laid down in layers
- in most cases, the oldest rocks are the rocks on the bottom and the youngest rocks are on the top



- This allows scientists to estimate the age of fossils by correlating the age of the rock with the rock above and below it.
- A cut through many rock layers therefore paints a picture of Earth History (ex. the Grand Canyon)

Fossil Evidence



- Fossils are evidence of organisms living in the past
- They can be direct evidence (ex. bones, hair, feathers) or indirect evidence (ex. molds, footprints)
- The harder the body material (ex. bone), the more likely it is to fossilize. For this reason, we have little fossil evidence of soft-bodied organisms without skeletons (but see the Burgess shale info)



Fossil Evidence

Scientists have found fossils of many organisms that are similar to, but with different morphology to, organisms alive today (crocodiles and saber toothed cats)

Fossils have also been found for species that are no longer present today indicating extinctions (dinosaurs and trilobites)



Fossil Evidence



In several locations in the fossil record, there appear to be mass extinctions where many species have gone extinct over a short period of time (K/T boundary)

All of this evidence suggests that many species have been present on the earth over its history and that they have changed over time, with some continuing to the present and others disappearing. (some dinosaurs → birds)



Biogeography Evidence

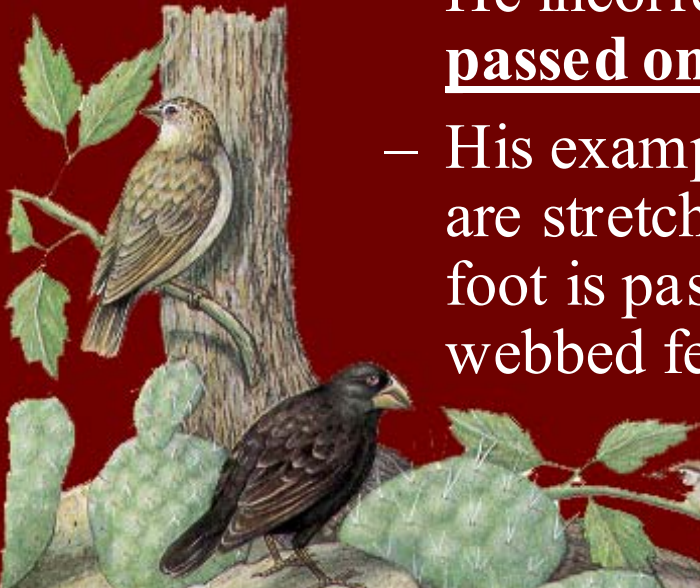
- **Biogeography** is the study of the geographical distribution of fossils and living species.
- Scientists have found living organisms and fossils above rocks where similar, older fossil organisms are found
- This supports the idea that species change over time, evolving into new species



Putting it all together

- **Lamarck**

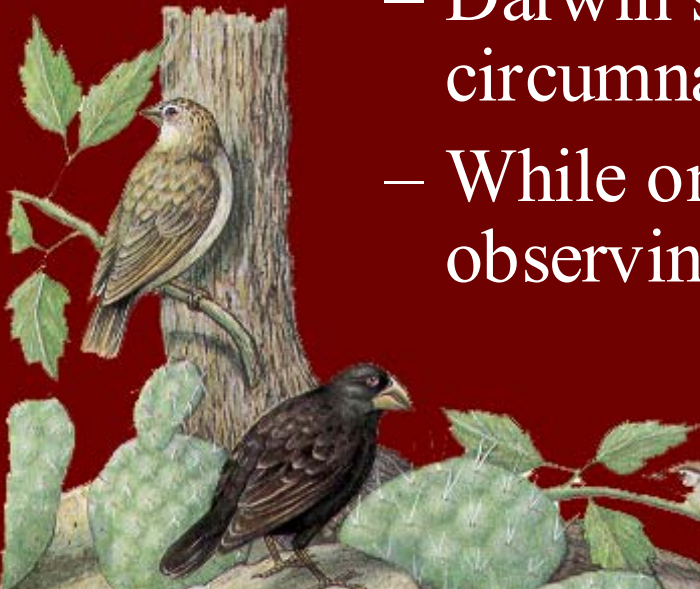
- Lamarck was one of the first people to try to put all of these data together into a single idea: species change over time
- He suggested that individuals can change their phenotype over their lifetimes
- He incorrectly assumed that any **acquired traits** are passed on to their offspring.
- His example was the webbing of duck feet. Duck feet are stretched over a duck's lifetime, and the stretched foot is passed on to its offspring. This results in fully webbed feet after several generations.



Putting it all together

- **Darwin**

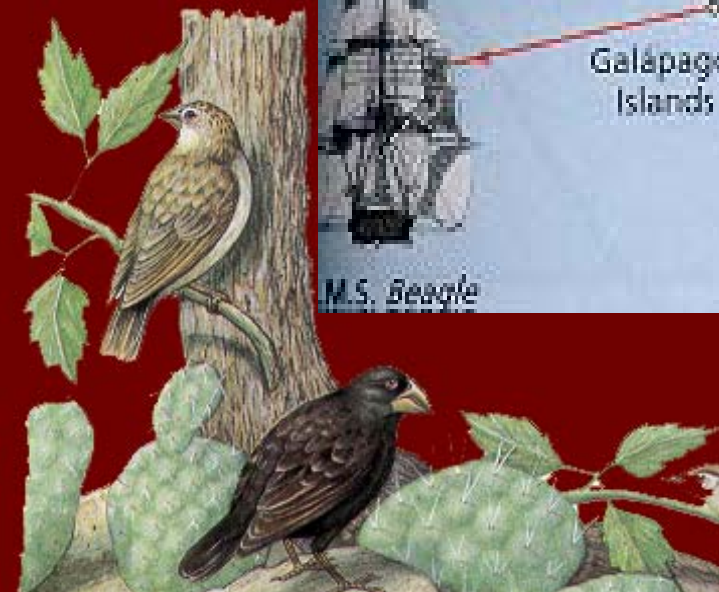
- Born in 1809, went to school for medicine and priesthood and didn't like either
- He was offered the position of naturalist on board the *HMS Beagle* in 1831.
- Darwin spend 5 years on this boat as it circumnavigated the globe
- While on this trip, Darwin visited lands, observing and collecting species as he went.



Voyage of the *Beagle*



M.S. *Beagle*



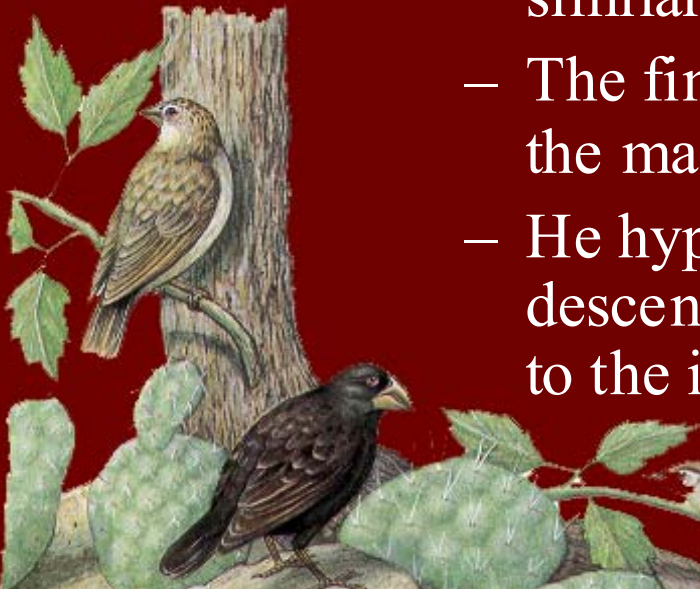
Putting it all together

- Darwin's ideas can be summarized by two principles
 - **Descent with modification**
 - **Modification by natural selection**

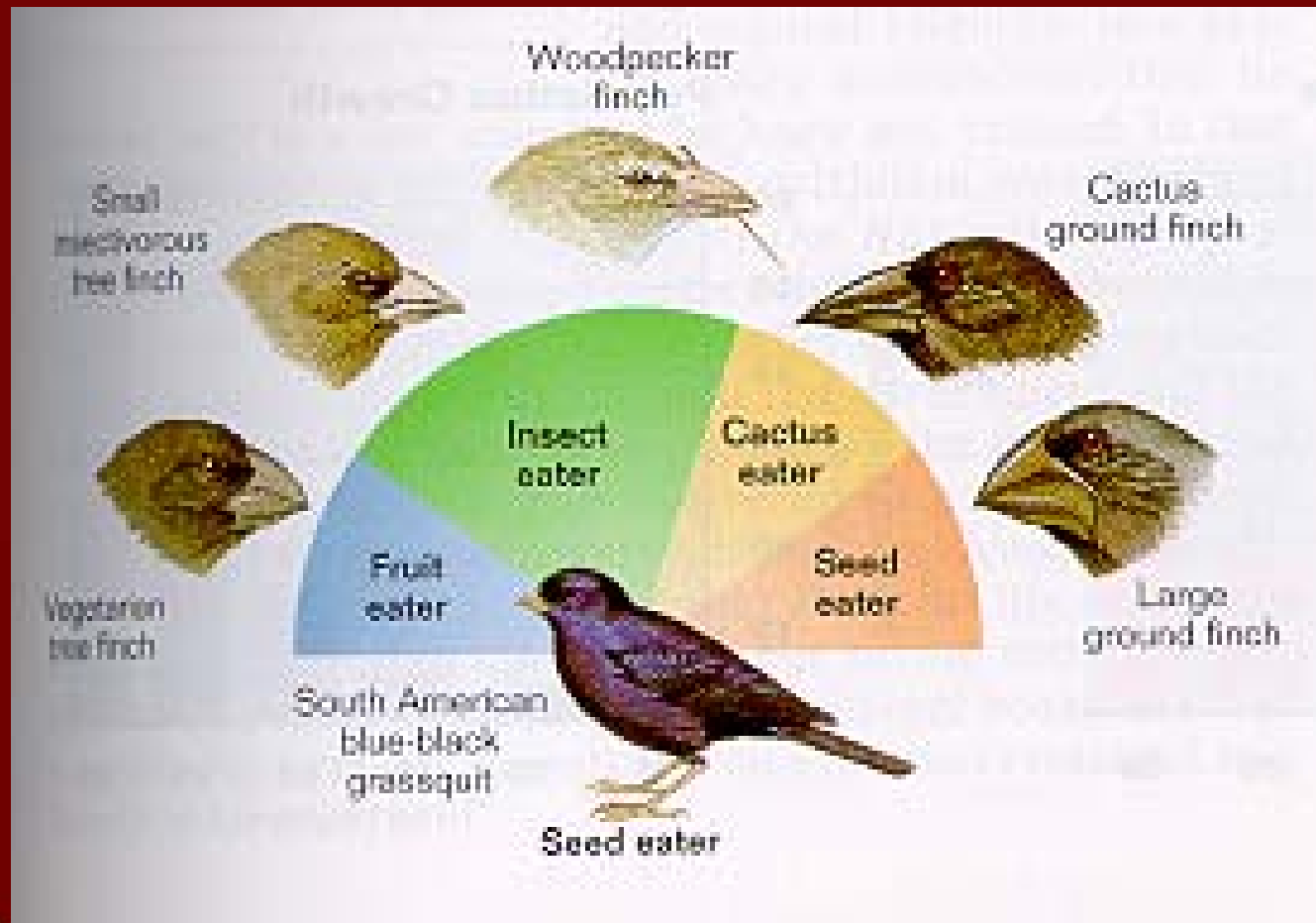


Descent With Modification

- New forms in the fossil record are the modified descendants of older forms
- All forms of life share common ancestors and are descended from a few original species
- Example: Galapagos Finches (*Geospiza*)
 - On his travels, Darwin found 13 distinct but similar finch species.
 - The finches appeared similar to a species found on the mainland.
 - He hypothesized that all 13 species were descended from one original species that traveled to the islands and evolved once there.



Descent With Modification



Modification By Natural Selection

- Malthus
 - Populations have the ability to grow (through reproduction) at a much faster rate than they actually do.
 - Something must limit the growth of populations
 - Examples: disease, famine, war
 - Suggested to Darwin that many individuals die, and there might be a specific reason why certain individuals survive, and others die (nonrandom process).



Modification By Natural Selection

- Darwin wondered if the environment creates struggles for individuals and species
- Within any population, there is genotypic and phenotypic variation. Ex. →
- Only those individuals with the traits most suited to the demands of the environment will be able to live and reproduce.



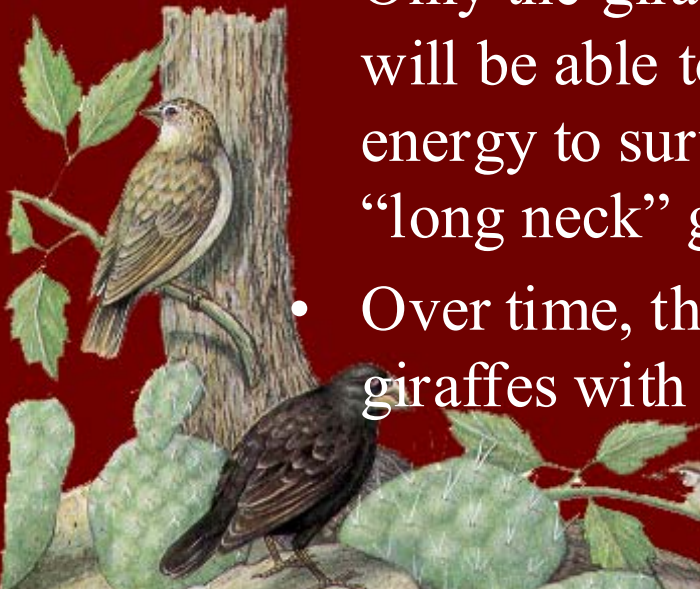
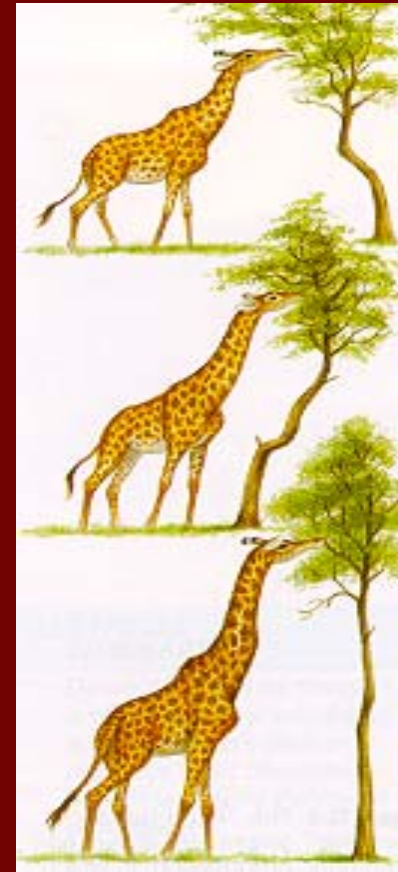
Modification By Natural Selection

- These successful individuals will then pass on these “good” genes (high **fitness**) to the next generation.
- Over time, the population will change showing more of the traits of the successful individuals.
- We say the species adapt to their environment.



Modification By Natural Selection

- Example: Giraffes
- Giraffes live in the savanna in Eastern Africa where the trees are very tall and hard to reach.
- In any population, there is variation in neck length (some longer, some shorter)
- Only the giraffes with the longest necks will be able to reach the food, and have the energy to survive and reproduce. The “long neck” genes get passed on.
- Over time, the population is made up of giraffes with longer necks.



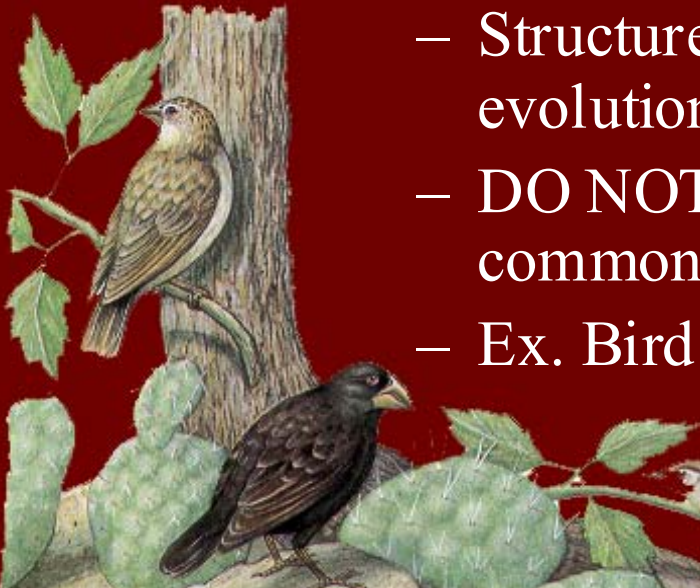
Evidence For Evolution

- **Homologous Structures**

- SHOW common ancestry
- Structures that are similar because of common descent
- Ex. Bat wing, whale flipper and dog paw

- **Analagous Structures**

- Structures with the same function, but different evolutionary history
- DO NOT show evolutionary relationships – no common ancestry
- Ex. Bird and insect wing, fish and dolphin fin



Evidence For Evolution

- **Vestigial Structures**

- Structures that serve little or no apparent function in modern organisms
- Evidence that the structure **WAS** functional in an ancestor to the modern form
- Ex. Human tailbone, whale pelvis
- The genes necessary to produce the vestigial structure have been retained (**conserved**), but they are no longer activated (except in rare cases).



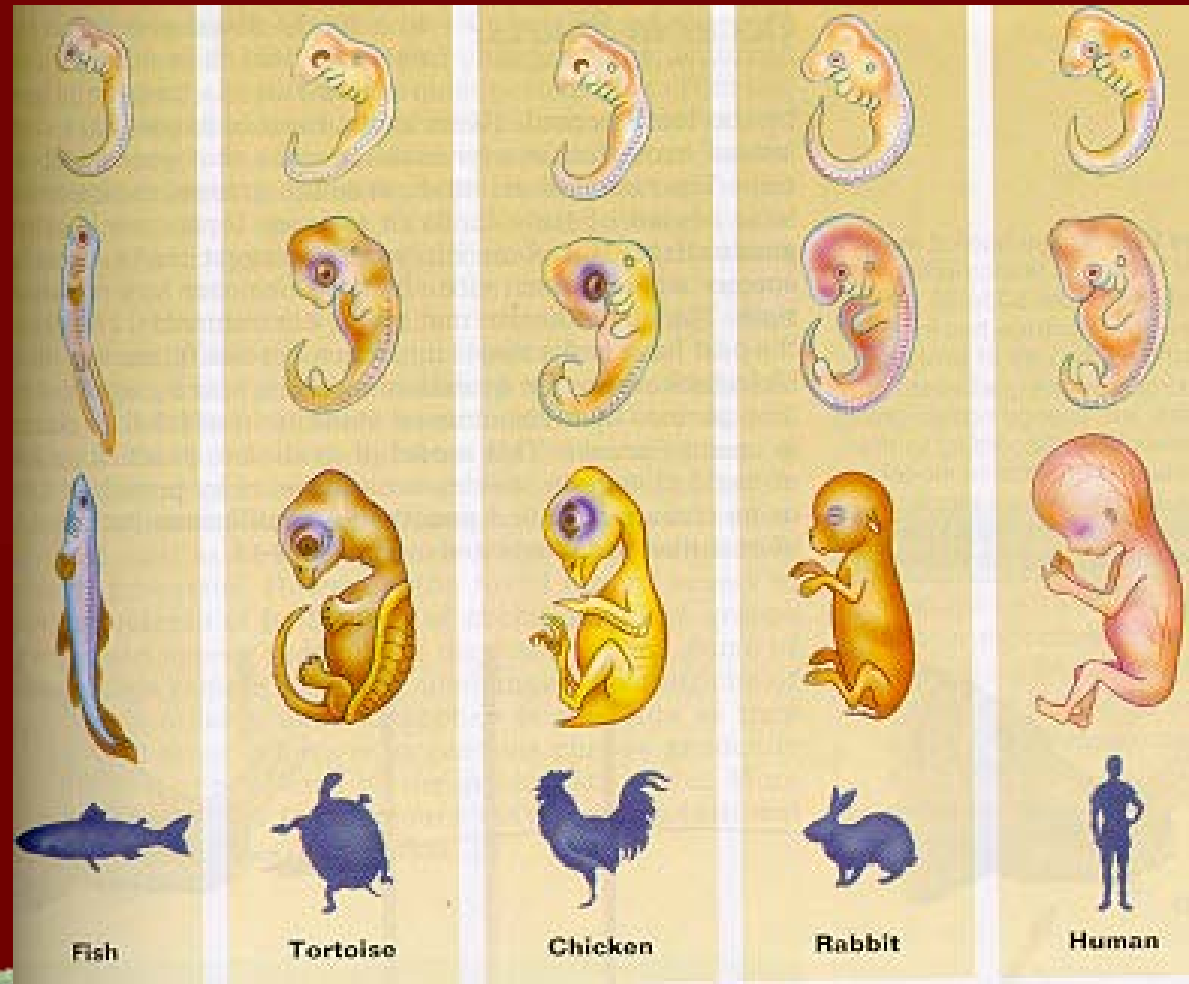
Evidence For Evolution

- **Similarities in Embryology**

- Ernst Haeckel stated that “ontogeny recapitulates phylogeny”
- Although organisms do not go through the adult stages of their ancestors, there is great similarity in embryological development of closely related species
- The more similar the development, the more closely related the species (remember echinoderm and chordate development)

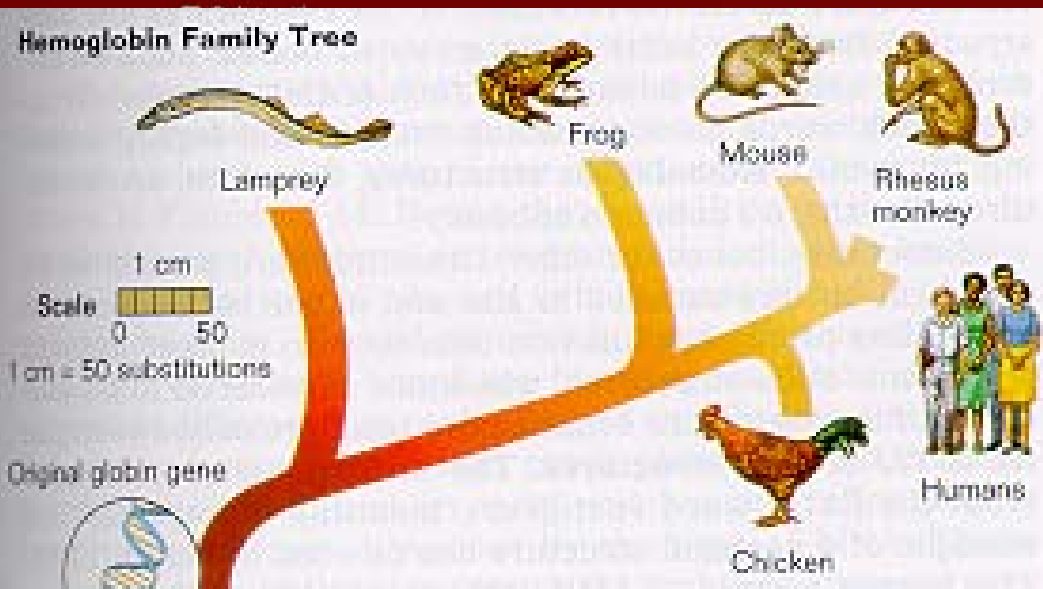


Similarities in Embryology



Evidence for Evolution

- Similarity in Macromolecules
 - Similarities in nucleotide or amino acid sequences can indicate common ancestry. Ex. a.a sequences in human and gorilla hemoglobin differ by only 1 a.a.



Species	Amino Acid Differences
	Compared with human hemoglobin
Gorilla	1
Rhesus monkey	8
Mouse	27
Chicken	45
Frog	67
Lamprey	125

Patterns of Evolution

- Coevolution

- When two species live in close association with each other over many generations they can evolve in response to each other
- This usually occurs in the case that the two species benefit from each other (ex. flower and pollinator) or one species is harmed by the interaction (ex. parasite and host)



Patterns of Evolution

- Convergent Evolution
 - Unrelated organisms inhabiting similar environments will evolve in similar ways resulting in similar morphology
 - Ex. sharks and dolphins
 - Hummingbirds and sunbirds
 - New world and old world vultures
 - Marsupial and placental mammals



Patterns of Evolution

- Divergent Evolution
 - Two or more populations or species with common ancestry become more dissimilar in response to evolution in different habitats
 - **Adaptive radiation**
 - Movement to a new habitat (Galapagos Is.)
 - **Artificial selection**
 - Divergence occurs much quicker than in nature due to manipulation by humans (domestic dogs)

